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heat at each stroke, which must be made up; the maximum heat in the wire-gauze apparatus is 30° below the heat in the cylinders; all the air in the cylinders must have supplied to it 60° of heat. At least one half a pound pressure to the inch, and probably much more, is required to force the air through the wire-gauze.

Dr. Bowditch alluded to the instrument called the "respirator," as analogous in its action to the wire-gauze in Ericsson's engine, in which the heat is often so retained as to be uncomfortable to the patient.

Professor Peirce observed that this apparatus of Ericsson was undoubtedly of great value for the working of his engine.

Professor Treadwell remarked that this same analogy to the "respirator" had been brought forward in 1847 in regard to Stirling's engine, which had an advantage over Ericsson's in using the same air over and over again. Air has an advantage of one half or two thirds over steam in the matter of specific heat, and if it could be used as conveniently without forcing-pumps, &c., it would be far superior as a motive power; but as yet the chief obstacles have not been removed.

Dr. W. F. Channing observed that Professor Peirce, in his calculations, had used the power necessary to double the speed in a given time as the *cube*, whereas, in the published accounts, it had been given as the *square;* and that thus so little power had been left (about $\frac{3}{4}$ lb. working power to the inch), that it seemed quite providential that the vessel had moved at all. To which it was replied, that when the element "space" is taken in the formula instead of "time," the *square* becomes doubled, or the *cube.*

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### Three hundred and seventy-fifth meeting.

February 1, 1853. — ADJOURNED QUARTERLY MEETING.

The PRESIDENT in the chair.

Professor Lovering reported that the map of the tornado at Medford was engraved, and that the report, by Professor

Eustis, was in the printer's hands, and would probably be finished in a few weeks.

Mr. Charles Jackson, Jr., in reference to the discussion at the last meeting on the Ericsson engine, said that the calculation showed that the efficient pressure was three fourths of a pound per inch in the up stroke, and nothing in the down stroke, or three eighths of a pound average. He did not believe this was enough to overcome the mere friction of the engine, and thought there must be an error in the facts on which the calculation that gave the result was based. He believed the air-engine, working at about 500°, and cutting off at one half or two thirds of the stroke, would give the same result as a non-condensing expansive steam-engine working with fifteen pounds of steam.

Steam at that pressure having about the same weight as common air, but the latent heat of the steam being twice the 500° the air required, and the capacity of water for heat being nearly four times that of air, the steam-engine required eight times as much fuel as the air-engine did. Half the power of the air-engine would be used in working the supply-pump, leaving the air-engine still four times better than the steam-engine even without any regenerator. The amount of heating surface required would be a great deal less with air than with water. In hot-blast iron smelting-furnaces which he has observed, there was five times as much air heated to 600° as there was water boiled off for the engine, and yet the hot-air ovens did not occupy one tenth of the room the boilers required.

Professor Treadwell remarked, that it was a matter of every day's observation, that in regard to the heat-conducting surface of iron necessary with air and with water, the advantage was very much in favor of water, even twenty to one.

Professor Peirce reaffirmed his statements at the preceding meeting, with a few modifications, not changing his general results. He said that accurate measurements by the Coast Survey showed that the actual speed of the Ericsson was only seven miles an hour, which, compared with the speed of the Collins steamers, would make the Ericsson consume twenty-five per cent. more fuel than the latter.

At the former meeting he had not considered the "cut-off," which gives a result more in favor of the Ericsson; though this advantage is compensated by the error he made in favor of the Ericsson engine by taking the heat of the cylinders at 480°, whereas the actual heat used was only 384°. The "cut-off" may be so short that the regenerator would be useless, the air going in and out at the same temperature, though more fuel would be required in this way. The shorter the "cut-off," the greater would be the theoretical power, provided you could get the air in. The "cut-off" in this engine is at three fourths of the stroke; for one fourth of the stroke there would be a pressure of three fifths above an atmosphere, and for the other three fourths of the stroke only one fifth above an atmosphere. One pound pressure would be required to force the air out through the wire-gauze, instead of the half-pound previously mentioned; and one and one fifth pounds pressure to force it in.

Dr. W. F. Channing remarked, that the difference in the loss of power from paddles entering the water (which is great in steam-vessels), and the less amount of friction, give more power to this engine. He thought, that, deducting one pound pressure (necessary to force the air through the wire-gauze) in place of half a pound allowed by Professor Peirce, there is a pressure of only one fourth of a pound left; and deducting from this 40 horse-power (equivalent to two fifths of a pound pressure, by Professor Peirce's calculation) for the loss from the paddles entering the water, and one fifth of a pound of pressure for additional friction, there would be a pressure of *minus seven twentieths of a pound* to an inch inside the cylinder, or, in other words, that the engine was worked by an *outside* atmospheric pressure acting inwards.

Professor Josiah Parsons Cooke and Professor Joel Parker of Cambridge were elected Fellows of the Academy; the former in the section of Chemistry, the latter in the section of Philosophy and Jurisprudence.

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### **Three hundred and seventy-sixth meeting.**

### March 1, 1853. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary announced that he had received a letter from Professor Parker accepting membership of the Academy. Professor Cooke took his seat as a Fellow.

Professor Treadwell observed, that the speed of the Ericsson in her trip to Washington was about six geographical miles an hour. He mentioned that hundred-gun ships, of a model far inferior to that of the Ericsson, had made nearly twelve miles an hour in trial trips in England, with steam-engines of 350 and 400 horse-power; as this was twice the velocity of the Ericsson, the power required would be eight times that of the Ericsson, which was far from the power used. The Ericsson consumed five tons and a fraction of coal a day; to get double the velocity, as in the English vessels, supposing the resistance the same (which it is not, on account of the vastly superior model of the Ericsson), about forty-five tons would be consumed, which is more than was consumed by the steam-vessels above mentioned. So that the experiment, after all, does not promise much in favor of the caloric engine.

Dr. W. F. Channing observed, that it is admitted that there is a saving of about one third of fuel in the caloric engine; that it must be an important improvement for stationary engines, even if it should not be found compact enough for sea-going vessels. An article in the Scientific American gives to the Ericsson 250 horse-power.

Professor Treadwell remarked, that very nearly as much power could be obtained from the amount of coal used by the Ericsson, if employed in the generation of steam, on account of the far greater expansive power of the latter.